

# EXHIBIT B

**Failure Analysis of Chart MVE 808AF-GB Cryopreservation Tank  
Serial Number CAB2112020013**

**Pacific Fertility Center Litigation**

**United States District Court  
Northern District of California  
San Francisco Division**

**Case No. 3:18-cv-01586-JSC**

**Date of Incident: Sunday, March 4, 2018**

**Location of Incident: Pacific Fertility Center  
55 Francisco Street, Suite 500, San Francisco, California 94133**

**Rebuttal Report prepared by:**

**Anand David Kasbekar, Ph.D.**

**File No. 1780**

**December 4, 2020**

## Additional Materials Reviewed

1. 2020-11-06 Eldon Leaphart Report
2. 2020-11-06 Ronald Parrington Report
3. 2020-11-16 Ronald Parrington Deposition
4. 2020-11-06 Franklin Miller Report
5. 2020-12-01 Franklin Miller Rough Draft Deposition
6. 2020-11-30 Virtual Inspection of Exemplar Tank Used by Franklin Miller
7. References as cited in this report

## Analysis and Discussion

Mr. Leaphart's report confirms that the subject Chart TEC 3000 Controller started malfunctioning on February 15, 2018, approximately 17 days prior to the March 4, 2018 incident.

[illegible]

Mr. Parrington does not provide an explanation for the cause of the incident that is supported by scientific analysis. [REDACTED]

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

[REDACTED]

[REDACTED]

Beach marks however are routinely found on fracture surfaces of components that have failed due to fatigue.<sup>2,3,4,5</sup> Volume 12 of the Metals Handbook states “The most distinct characteristic of fatigue failures in the field are the beach marks or clam shell markings on the cyclically grown portion of the fracture”.<sup>6</sup> This authoritative and well respected reference further states “The presence of beach marks is fortuitous, at least for the investigator, because beach marks permit the origin to be easily determined...” [REDACTED]

[REDACTED]

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<sup>1</sup> Ronald Parrington Report of November 6, 2020, p. 32 Figure 35.

<sup>2</sup> D. Hull, Fractography Observing, Measuring, Interpreting Fracture Surface Topography, Cambridge University Press, 1999, p. 332-333.

<sup>3</sup> L. Engel and H. Klingele, An Atlas of Metal Damage, Prentice Hall, 1981 p. 84-85

<sup>4</sup> ASM Metals Handbook Volume 9 8<sup>th</sup> Edition Fractography and Atlas of Fractographs p. 455.

<sup>5</sup> Journal of Failure Analysis and Prevention Volume 5(2) April 2005, ASM International p. 11-15

<sup>6</sup> ASM Handbook Volume 12 Fractography p. 111-112, 358-359.

<sup>7</sup> A. Griebel Technical Brief: Fatigue Dimples, Journal of Failure Analysis and Prevention Volume 9 2009, ASM International p. 193-196

Fatigue failure is a known issue affecting cryogenic storage tanks.<sup>8,9,10,11,12</sup> Despite the presence of several features that are strong indicators of progressive fracture or fatigue, Mr. Parrington rules out fatigue in favor of monotonic overload because the “failure scenario involving fatigue is quite complicated” and “monotonic ductile overload is much more straightforward”. I strongly disagree with this conclusion which fails to reasonably account for the fractographic features that indicate fatigue failure. Mr. Parrington does not provide a reasonable scientific explanation for the observed beach marks other than fatigue. [REDACTED]

[REDACTED] In fact, contraction of the fill line would create an upward bending load on the fitting and put the root of the weld in tension (crack opening loading) where severe stress risers exist.

<sup>8</sup> Nishimura, A. and Mukai, Y., “Cold Thermal Fatigue of Austenitic Stainless Steel”, Advances in Cryogenic Engineering (Materials), Vol. 38, Edited by F.R. Fickett and R.P. Reed, Plenum Press, New York, 1992.

<sup>9</sup> I.K. Heo, D.H. Yoon, J.H. Kim, H.C. Kim, K.D. Kim, “Fatigue crack propagation behavior in AISI 304 steel welded joints for cold-stretched liquefied natural gas (LNG) storage tank at cryogenic temperatures”, Materialwiss. Werkstofftech. 2019, 50, 580-587.

<sup>10</sup> Y.K. Yoon, J.H. Kim, K.T. Shim, "Mechanical Characteristics of 9% Ni Steel Welded Joint for LNG Storage Tank at Cryogenic", Advanced Materials Development and Performance, International Journal of Modern Physics: Conference Series Vol 6 (2012) 355-360. World Scientific Publishing Company.

<sup>11</sup> Edeskuty F.J., Stewart W.F. (1996) Stresses Caused by Thermal Contraction. In: Safety in the Handling of Cryogenic Fluids. The International Cryogenics Monograph Series. Springer, Boston, MA. [https://doi.org/10.1007/978-1-4899-0307-5\\_4](https://doi.org/10.1007/978-1-4899-0307-5_4)

<sup>12</sup> Health and Safety Executive: *Safety alert Restricted pipe movement withing perlite vacuum insulated static cryogenic tanks of capacity above 1000 litres*. Pages 1-5

<sup>13</sup> Understanding How Components Fail, 2<sup>nd</sup> Edition, ASM International p.1-11

I have been involved in the field of failure analysis for over 35 years. I have investigated numerous failures that were clearly due to fatigue in which fatigue striations could not be resolved. It is particularly noteworthy that Volume 11 of the Metals Handbook specifically states that fatigue fracture surface “*may* show striations at magnifications above 500x” (emphasis added).<sup>14</sup> It is also noteworthy that the area which appears striation-like is resolved at 500x and above, and best observed at 1000x and above. Since I am not able to conclude that these are in fact fatigue striations, without conducting additional SEM investigation, I did not rely upon this feature in forming my opinion. However, the orientation of these striation-like features is consistent with a fracture origin at the weld root. Additionally, the location of the striation-like features is on an undamaged region of the fracture that is below and therefore protected by the surrounding fracture surface. It is in these protected low-lying areas where striations are commonly found on damaged fatigue fracture surfaces. While additional investigation would be necessary to draw a reliable conclusion regarding the specific nature of these striation-like marks, they could be consistent with the other conclusive fatigue characteristics observed on this fracture surface.

While I am not comfortable relying solely on these “striations.” they should not be completely discounted, as they are consistent with the other documented fatigue fracture features. Additionally, it is not unusual for an investigator to be unable to find or resolve fatigue striations even on failures that are known to be due to fatigue. Even with substantial efforts to search for fatigue striations at high magnification it is often the case that they can’t be found despite the fracture being a result of fatigue. [REDACTED]

<sup>14</sup> Tanzer, A., “Determination and Classification of Damage”, ASM Handbook, Volume 11, Failure Analysis and Prevention, 2002, p. 345, Table 1.

[REDACTED]

[REDACTED] Laboratory fractures are generally more pristine than field fractures and therefore striations are more readily imaged. In practice, fatigue striations can be difficult or impossible to observe on fracture surfaces and these striations are even more difficult to observe in weld metal.<sup>15</sup> It is well known that the absence of fatigue striations does not prove that the failure was not due to fatigue.<sup>16,17</sup> The subject tank is constructed from a 304 stainless steel which is an austenitic stainless steel. The Parrington report shows multiple examples of striations in 300 series stainless seemingly to imply that striations should have been readily visible on the subject fracture if the failure was due to fatigue. This logic is incorrect and potentially misleading not only for the reasons discussed above but also because fatigue striations in austenitic stainless steel have been reported to be relatively difficult to detect.<sup>18</sup>

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

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<sup>15</sup> Tang, L.; Qian, C.; Ince, A.; Zheng, J.; Li, H.; Han, Z. Fatigue Crack Growth Behavior of the MIG Welded Joint of 06Cr19Ni10 Stainless Steel. *Materials* **2018**, *11*, 1336.

<sup>16</sup> American Society for Metals, & ASM International. (1987). ASM Handbook: Volume 12 Fractography. p. 118-119.

<sup>17</sup> 2020-11-16 Deposition of Ronald Parrington, 68:23-69:1

<sup>18</sup> Journal of Failure Analysis and Prevention Volume 5(2) April 2005, ASM International p. 11-15

<sup>19</sup> Ronald Parrington Report of November 6, 2020, p. 4

[REDACTED]

[REDACTED]

[REDACTED] I was present during the removal of the false bottom which involved substantial efforts to cut and remove it from the deformed tank. Mr. Parrington was not present during the cutting and removal of the false bottom. While the false bottom removal was done in a careful manner, it was not a precision operation given the difficulty accessing the bottom of the tank and the need to make multiple cuts and manipulate and free the cut pieces from the damaged tank. It is likely that the forces and significant vibrations that took place during this process contributed to or caused the observed mark on the weld face. Mr. Parrington testified that he did not see any photographs showing the false bottom in contact with the weld face and could not say whether or not the witness mark was present prior to removal of the false bottom.<sup>20</sup>

I disagree that the observed contact between the false bottom and the weld which could have occurred during removal of the false bottom or possibly during the deformation (after nitrogen pressurized the vacuum space) is a reasonable explanation for why the fill port weld cracked but the sense port weld did not. Mr. Parrington provides no analysis to support this conclusion, and he can't say if the witness mark was present prior to removal of the false bottom. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

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<sup>20</sup> 2020-11-16 Deposition of Ronald Parrington 72:15-17, 74:21-75-1

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED] Contrary to Mr. Parrington's assertion that it is hard to fathom very high cyclic stress in the annular lines, the thermally induced cyclic stress is actually very high in the area of the weld root due to contraction of the annular line from cooling. This is the precise area where I concluded that this failure initiated, and this analysis further supports my findings and is consistent with the literature and Dr. Miller's testimony related to thermal contraction in cryogenic equipment<sup>26,27,28</sup>. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

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<sup>21</sup> Id. 85:4-23

<sup>22</sup> Id. 117:19-25

<sup>23</sup> Id. 176:10-13

<sup>24</sup> Understanding How Components Fail, 2<sup>nd</sup> Edition, ASM International p.1-11

<sup>25</sup> Edeskuty F.J., Stewart W.F. (1996) Stresses Caused by Thermal Contraction. In: Safety in the Handling of Cryogenic Fluids. The International Cryogenics Monograph Series. Springer, Boston, MA. [https://doi.org/10.1007/978-1-4899-0307-5\\_4](https://doi.org/10.1007/978-1-4899-0307-5_4)

<sup>26</sup> Id.

<sup>27</sup> Health and Safety Executive: *Safety alert Restricted pipe movement withing perlite vacuum insulated static cryogenic tanks of capacity above 1000 litres*. Pages 1-5

<sup>28</sup> 2020-12-1 Rough Draft Deposition of Franklin Miller 226:5-10

[REDACTED]

[REDACTED]

[REDACTED]

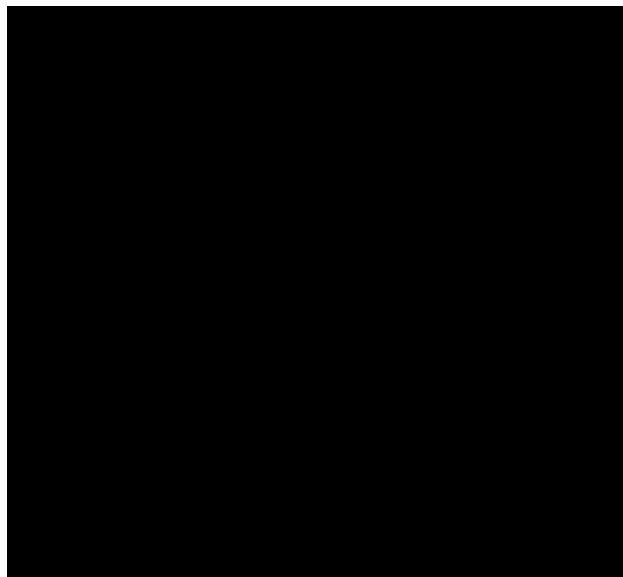
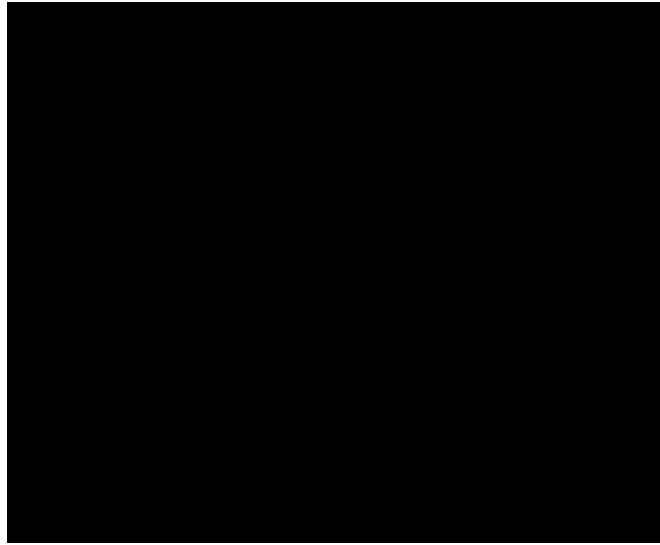
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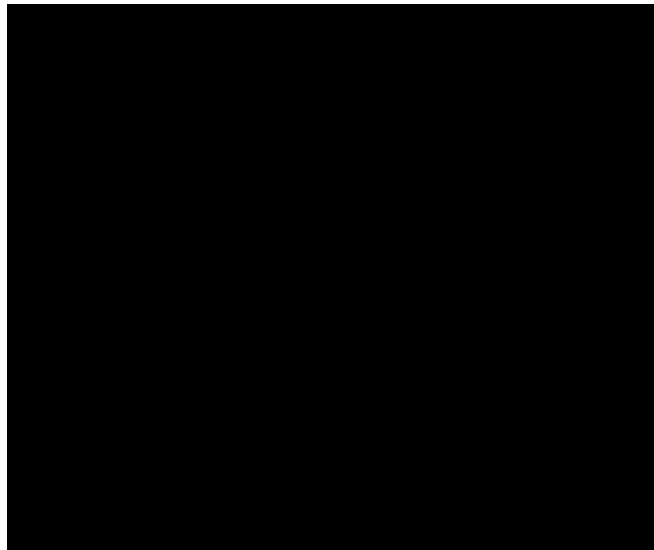
<sup>29</sup> 2020-12-01 Rough Draft Deposition of Franklin Miller 229:15-21

<sup>30</sup> Edeskuty F.J., Stewart W.F. (1996) Stresses Caused by Thermal Contraction. In: Safety in the Handling of Cryogenic Fluids. The International Cryogenics Monograph Series. Springer, Boston, MA. [https://doi.org/10.1007/978-1-4899-0307-5\\_4](https://doi.org/10.1007/978-1-4899-0307-5_4)

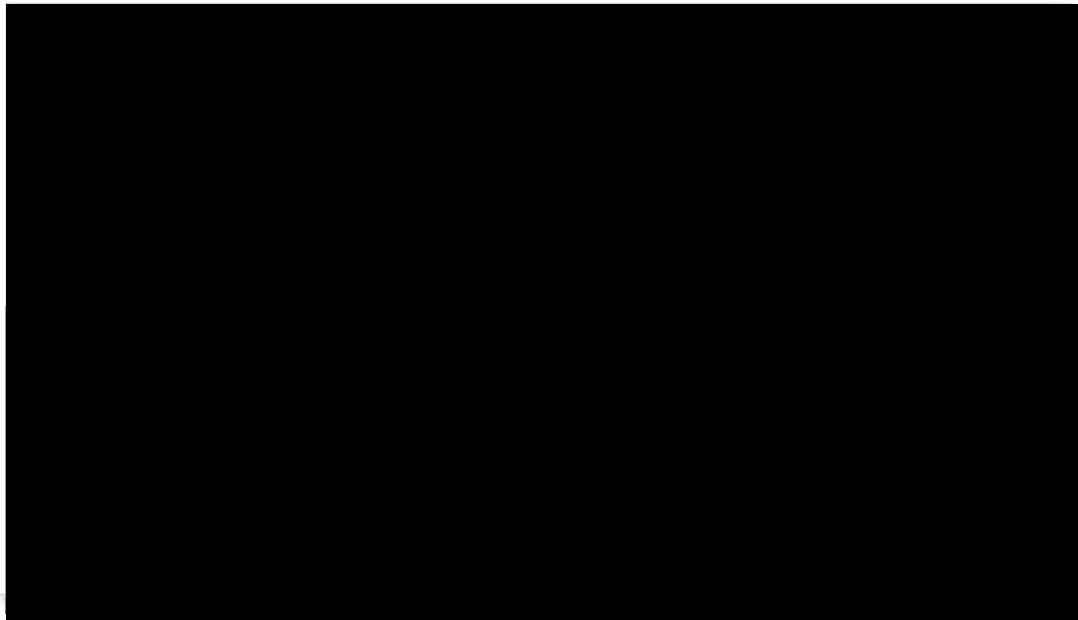
<sup>31</sup> Health and Safety Executive: *Safety alert Restricted pipe movement withing perlite vacuum insulated static cryogenic tanks of capacity above 1000 litres*. Pages 1-5







[REDACTED]



[REDACTED]

[REDACTED]

It should be noted that early in this investigation, [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

This more recent response is consistent with the apparent and classic buckled beam shape of the fill and sense lines which ultimately appear to have been subjected to nearly identical compressive loads during the final buckling or implosion of the inner tank. Dissection of an exemplar MVE 808 tank was consistent with the fill and sense lines not being bent to reduce such stresses. It is my opinion that the design of the subject tank should have included bends in these lines (especially the fill line) to reduce thermally induced loading and the resulting stress on the weld that joins the annular line to the inner tank wall where this failure occurred. The use of such bends, which create a horizontally oriented section of the tubing, would have significantly reduced the stresses at the weld joint. This opinion is supported by basic engineering principles, finite element analysis, and published literature pertaining to cryogenic equipment.<sup>34,35</sup>

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

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<sup>32</sup> Understanding How Components Fail, 2<sup>nd</sup> Edition, ASM International p.1-11

<sup>33</sup> 2020-11-16 Deposition of Ronald Parrington, 166:13-17

<sup>34</sup> Id.

<sup>35</sup> Health and Safety Executive: *Safety alert Restricted pipe movement withing perlite vacuum insulated static cryogenic tanks of capacity above 1000 litres*. Pages 1-5

contraction of a 26 inch length of fill line if at room temperature when subjected to liquid

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Defense experts' Mr. Parrington and Dr. Miller fail to provide a reasonable explanation backed by sound scientific analysis for the rapid depletion of liquid nitrogen and the subsequent tank implosion. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

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<sup>36</sup> Ronald Parrington Report of November 6, 2020, p. 7

[REDACTED]

Defense experts discount features that indicate the fracture occurred in a progressive manner and speculate regarding an undetectable slow leak that they did not attempt to locate or analyze because it was allegedly masked during Exponent's efforts to digitize the damaged tank or altered during the removal of the vacuum plug. [REDACTED]

[REDACTED]

[REDACTED] If defense experts believe a slow leak or the vacuum plug was the most probable source of nitrogen leaking into the vacuum space, then at a minimum they should have attempted or requested to clean the inner tank and test for the alleged slow leak. Positive pressure applied to the vacuum space from the leak test protocol that was agreed upon by all parties including Chart and their retained experts would likely have cleared any alleged particles or other substances that Mr. Miller claimed possibly could have blocked a slow leak. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED] Despite extensive leak testing and flow rate testing using equipment specified by Chart's expert, there was no indication of a slow leak.

Chart's experts also made no attempt to closely examine the vacuum port plug nor reinstall and test the vacuum port plug. Examination and testing of the vacuum port and vacuum port plug were feasible and could have been conducted by Chart's experts despite the removal of the vacuum plug.<sup>38</sup> Chart's experts apparently chose not to examine the vacuum port and plug for any evidence of degradation, damage, or a leak site but now claim that such a leak may have existed without any effort to substantiate the claim. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

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<sup>37</sup> 2020-12-01 Rough Draft Deposition of Franklin Miller 140:10-17

<sup>38</sup> Id. 138:12-139:1-7

<sup>39</sup> 2020-11-06 Report of Franklin Miller p. 7

[REDACTED] These two statements are conflicting, and given the only detected leak site was at the failed fill port weld and that defense experts chose not to closely and thoroughly inspect nor test the removed vacuum plug or vacuum port, it is mere speculation unsupported by science to suggest that the vacuum port was the source of the leak that resulted in this incident.

[REDACTED]

[REDACTED]

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<sup>40</sup> 2020-12-01 Rough Draft Deposition of Franklin Miller 133:13-17

<sup>41</sup> 2020-11-16 Deposition of Ronald Parrington 91:1-20

<sup>42</sup> Id. 92:22-93:13

<sup>43</sup> 2020-12-01 Rough Draft Deposition of Franklin Miller 208:7-12

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

In addition to relying on a research paper for a different manufacturer's sieve material, the remainder of Dr. Miller's analysis is based on theoretical calculations which assume that 100% of the adsorbed nitrogen would be released at room temperature [REDACTED]

[REDACTED]

[REDACTED] To the best of my knowledge his analysis does not account for the degree to which the sieve material that was weighed in March of 2020 may have been saturated with gas and moisture from being exposed to ambient conditions after the loss of vacuum in March of 2018. He did no testing of the subject sieve material to show that it would outgas to a level that would cause the implosion and deformation that was observed in Tank #4. Dr. Miller's theory is that a slow loss of vacuum caused the sieve material to become saturated with nitrogen and then as the liquid nitrogen evaporated from the tank, the sieve warmed to room temperature releasing enough gas to severely implode the tank. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED] There is no evidence nor documentation to support such occurrences. Such occurrences are also inconsistent with Chart's own advice that end-users completely defrost tanks every five years. Even Dr. Miller admits that he has never seen an inner vessel deform from a spoiled (loss of) vacuum prior to this litigation.<sup>46,47,48</sup>

[REDACTED]

[REDACTED]

[REDACTED]

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<sup>44</sup> L.C. Yang, T.D. Vo and H.H. Burris, Nitrogen Adsorption Isotherms for Zeolite and Activated Carbon., Cryogenics December 1982. p. 634

<sup>45</sup> Id. p. 626

<sup>46</sup> 2020-12-01 Rough Draft Deposition of Franklin Miller 32:1-5

<sup>47</sup> Id. 54:8-14

<sup>48</sup> Id. 55:6-16

[REDACTED]

[REDACTED]

[REDACTED] Furthermore, I disagree that Dr. Miller's experiment disproves Jean Popwell's testimony that she filled Tank #4 to 14 inches on March 3, 2018, the day prior to the incident. Dr. Miller concludes that when the staff left on March 3<sup>rd</sup> Tank #4 "likely would have had to be less than 8 inches..."<sup>50</sup> At that level the contents of the tank would have been exposed and noticeable to Ms. Popwell. There is no evidence nor testimony that Ms. Popwell would have filled the tank or left the tank at a level that exposed the tank contents. Dr. Miller's experiment does not reproduce the conditions in Tank #4 from the time the tank was filled by Popwell. Nor does his testing account for the possibility and probability of an internal breach between the inner tank and vacuum space. [REDACTED]

[REDACTED]

[REDACTED] Dr. Miller does not know what the vacuum level was in Tank#4 when it was last filled on the day prior to the incident. His experiment does not replicate the conditions between the time Jean Popwell last filled the tank and the incident. Dr. Miller simply proves that the

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<sup>49</sup> 2019-12-13 Deposition of Anand Kasbekar 71:8-15

<sup>50</sup> 2020-12-01 Rough Draft Deposition of Franklin Miller 102:16-19

<sup>51</sup> 2020-12-1 Rough Draft Deposition of Franklin Miller 105:1-4 and 109:18-110:4

conditions he subjected his exemplar tank to do not replicate the Tank #4 failure or any of the circumstances that the eyewitnesses at PFC described and testified to in deposition..

[REDACTED]

Whether or not Tank #4 imploded and deformed due to a slow, moderate, or rapid leak of nitrogen into the vacuum space, the most probable cause of the loss of cooling and subsequent implosion is the crack through the incomplete penetration weld of the fill port. In my opinion none of the experts have or can accurately quantify the leak rate through the crack opening which progressed over time and ultimately changed significantly due to the final implosion of the tank.

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<sup>52</sup> 2020-11-16 Deposition of Ronald Parrington 92:17-18

<sup>53</sup> 2020-12-01 Rough Draft Deposition of Franklin Miller 105:1-6

<sup>54</sup> Id. 146:7-15

<sup>55</sup> Id. 211 19-21

All of the above opinions are to a reasonable degree of scientific certainty based upon the currently available information and materials. If additional materials become available or if further work is warranted, I reserve the right to revise or amend these opinions.

**Qualifications and Compensation**

My qualifications and compensation, along with my prior testimony and publications, are fully addressed in my primary report submitted on November 6, 2020 and amended on November 30, 2020.

A handwritten signature in dark ink, appearing to read 'ADK', followed by a horizontal line.

Anand David Kasbekar, Ph.D.

12/4/2020  
Date